UNIVERSITI TEKNIKAL MALAYSIA MELAKA

To Investigate Effect of Strengthener Variation in Mechanical Properties of Metal Matrix Composite

This report submitted in accordance with requirements of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Engineering Material) with Honours.

By

GANESH KUMAR A/L KRISHNAN

FACULTY OF MANUFACTURING ENGINEERING

2009

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PSM

JUDUL:

To Investigate Effect of Strengthener Variation in Mechanical Properties of Metal Matrix Composite

SESI PENGAJIAN:
Semester 2 2008/2009

Saya **Ganesh Kumar A/L Krishnan**
mengaku membenarkan laporan PSM / tesis (Sarjana/Doktor Falsafah) ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM / tesis adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM / tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4.
5. *Sila tandakan (√)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
√	TIDAK TERHAD	

Disahkan Oleh:

(TANDATANGAN PENULIS)
Alamat Tetap:
No. 222, Jalan Wira Indah 2,
Taman Wira Indah,
78100, Lubok Cina,
Melaka.

(TANDATANGAN PENYELIA)

Cop Rasmi:

Tarikh: 16 April 2009

Tarikh:

* Jika laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declare this report entitled "To Investigate Effect of Strengthener Variation in Mechanical Properties of Metal Matrix Composite" is the results of my own research except as cited in references

Signature	:	
Author's Name	:	**Ganesh Kumar A/L Krishnan**
Date	:	16 April 2009

APPROVAL

This report submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Engineering Material). The members of the supervisory committee are as follow:

………………………………………

En. Mohamad Haidir Bin Maslan

Supervisor

(Official Stamp and Date)

ABSTRACT

The composites material is considered to be any multiphase such that exhibits a significant proportion of the properties of both constituent phases such that a better combination of properties is realized. The purpose of investigation of strengthener variation in mechanical properties of metal matrix composite was developed is to investigate the mechanical properties of metal matrix composite reinforced different geometry size and shape of reinforcement. Aluminum was chosen as the matrix material and low carbon steel as the reinforcement in the form of continuous rod and woven rod. There also differences in the reinforcement diameter been used among the sample. Mould was made from low carbon steel along with the jig. The jig is used to arrange the reinforcement orderly during casting process. The composite is fabricated by using on of the pressureless metal infiltration process which is stir casting technique. The amount of matrix and reinforcement used is about 95 % and 5 % from the finish part respectively. The composites properties among each sample with different geometry shape and size are compared. To make a comparison, investigation of mechanical properties of composites which is tensile test and charpy impact test conducted under ASTM D3552 and E23 standard respectively. The Scanning Electron Microscope (SEM) machine also used to study the interphase between matrix and reinforcement. The result shows that, reinforcement with geometry of woven form have better mechanical properties compare to the other two specimens with continuous form of reinforcement.

ABSTRAK

Bahan komposit adalah bahan yang terhasil daripada gabungan dua bahan yang berlainan digabungkan untuk mendapatkan sifat bahan yang lebih baik. Projek ini dijalankan bertujuan mengkaji sifat mekanikal komposit diantara komposit yang mempunyai variasi dalam saiz dan bentuk tetulangya. Aluminium dipilih sebagai bahan pengikat manakala besi dipilih sebagai tetulangnya dimana ianya dalam bentuk dawai lurus dan juga dawai yang telah dipintal. Terdapat juga perbezaan dalam diameter dawai yang digunakan antara sampel. Acuan untuk menghasilkan komposit ini dihasilkan menggunakan besi berserta dengan jig. Jig digunakan untuk menyusun dawai besi ini secara seragam ketika penuangan dilakukan. Kaedah penuangan tanpa mengaplikasi tekanan digunakan untuk menghasilkan bahan komposit ini. Komposisi bahan yang digunakan untuk pengikat dan tetulang adalah 95 % dan 5 % daripada jumlah keseluruhan. Sifat mekanikal komposit ini dibandingkan antara sampel yang dihasilkan yang mempunyai variasi dalam tetulangnya. Untuk membuat perbandingan sifat mekanikal, ujian hentaman charpy dan ujian tegangan dijalankan mengikut standard ASTM E23 dan D3552. Scanning Electron Microscope (SEM) juga digunakan untuk mengkaji keadaan antarafasa diantara matrik dan tetulang. Hasil kajian menunjukkan komposit dengan tetulang yg dipintal mempunyai sifat mekanikal yang lebih baik berbanding dua sampel lain yang menggunakan tetulang biasa.

DEDICATION

This thesis is gratefully dedicated to my family and all my friends.

ACKNOWLEDGEMENT

First and foremost, I would like to thank god for His blessing. Without gods bless I will not be able to complete this research as required and without the help and support from certain groups and individual it will be impossible for me to finish up this research.

Not to forget, my deepest appreciation to Mr. Mohamad Haidir Bin Maslan, my supervisor and other lecturers who had given me endless help, guidance, and support me to make up with the standard as required as a mechanical engineer student during the research.

I also want to thank to UTeM management especially manufacturing faculty management for giving me opportunity to get more experiences and knowledge during the period of the research.

Finally, I am also indebted to all those people who have directly or indirectly helped to make my final year project stint an incredible journey of knowledge and self improvement.

Thank you.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Al	-	Aluminum
Al_2O_3	-	Aluminum Oxide
ASTM	-	American Society for Testing and Materials
BaO-MgO-Al_2O_3-SiO	-	Barium-Magnesia-Alumina-Silicate
BBC	-	Body Centered Cubic
CMC	-	Ceramic Matrix Composites
Cu	-	Copper
E	-	Modulus of Elasticity
e.g.	-	For example
K	-	Kelvin
Li_2O-Al_2O_3-SiO	-	Lithiumaluminasilicate
Mg	-	Magnesium
MgO-Al_2O_3-SiO	-	Magnesia-Alumina-Silicate
MMC	-	Metal Matrix Composites
mm	-	Millimeter
Mn	-	Mangan
Pa	-	Pascal
PEEK	-	Polyetheretherketone
PEI	-	Polyetherimide
PPS	-	Polyphenylene Sulfide
PMC	-	Polymer Matrix Composites
SEM	-	Scanning Electron Microscope
SiC	-	Silicon Carbide
Si_3N4	-	Silicon Nitride
TiB_2	-	Titanium Boride
UTS	-	Ultimate Tensile Strength
ZrO_2	-	Zirconium Oxide
Zn	-	Zink

LIST OF SYMBOLS

%	-	Percent
σ_f	-	Tensile Strength of the Fiber
τ_c	-	Shear yield Strength of the Matrix
σ_y	-	Yield Strength,
σ	-	Tensile Strength
^{0}	-	Degrees
^{0}C	-	Degrees Celsius
^{0}F	-	Degrees Fahrenheit
±	-	Plus and minus
μm	-	micrometer

CHAPTER 1

INTRODUCTION

1.1 Research Background

Based on the project title, "effect of strengthener variation in mechanical properties of metal matrix composite" the project is conducted in consequence to study the mechanical properties of aluminum reinforced low carbon steel with different geometry shapes such as rod in continuous and woven form and also with different diameter size. These reinforcements are embedded into the matrix (aluminum) and their mechanical properties are compared and analyzed.

Metal Matrix Composites (MMC) has been paid much attention and used extensively in industry over several years due to its excellent mechanical and thermal properties. Interest in MMC for used in the aerospace and automotive industries, and other structural applications, has increased over the past 20 years as a result of the availability and relatively inexpensive reinforcements (Kalpakjian, S., 2000). The family of discontinuous reinforced MMCs includes both particulate and whiskers or short fibers and this class of MMCs has attracted considerable attention.

Hot press closed mold is a molding process used to produce the composite. The aluminum reinforced low carbon steels with different geometry shape properties were compared among each other to study the material properties. To obtain the mechanical properties, tensile test, and Charpy impact test and others conducted under ASTM standards to determine the toughness, tensile strength, yield strength and modulus of elasticity.

1.2 Purpose of Research

The purpose of this research is to study and analyze the mechanical properties of aluminum reinforced with different shape of geometry of low carbon steel as a comparison. The mechanical properties parameters observed are tensile properties, impact properties and microstructure analyses.

1.3 Problem Statements

Previously, metal matrix composite used other than metal as their reinforcement such as ceramic. In this project metal-matrix composite were introduced and investigated which consist of metal as matrix and metal as reinforcement. Using the good properties of each metal with different melting point, better mechanical properties of composite expected to be produced. The aluminum metal matrix composites commonly used discontinuous fiber as reinforcement; the problems that widely occurred during processing are; non uniform of fibers distribution (Matthews, F.L. and Rawlings, R.D., 1999).The study is also applying different geometry shape of reinforcement into the aluminum metal matrix composite and analyzing the mechanical properties of the material produced. The geometry of the reinforcement is in continuous and woven form.

1.4 Objectives

Upon conducting the effect of strengthener variations in metal matrix composite, some of the objective are expected to be meet among them are as follow:

(a) To compare the mechanical properties of metal-metal composites (MMC) with the effect of strengthener variations.
(b) To obtain mechanical properties from the composite produced and study the best reinforcement types among the types been used.

1.5 Scope of Study

This study focus on the investigations of strengthener variations in metal matrix composite of aluminum reinforced with geometry shape of low carbon steel in continuous and woven form. The properties of the composite compared among the composite produced with these different geometry shapes and size. The composite produced by stir casting technique, a type of casting process. Tensile test and impact test conducted to investigate the mechanical properties of composite in longitudinal direction along side with SEM surface observation. The testing used to obtain the tensile strength, modulus of elasticity, yield strength and toughness. Microstructure studies under microscope done to understand and analyze the physical properties as many of the physical properties are predicted on a knowledge of the microstructure of the material.

1.6 Research Question

(a) Will reinforcement increase the mechanical properties of a composite?
(b) Is different geometry shape of reinforcement influence the mechanical properties?

1.7 Hypotheses

The reinforcement will increase the material properties of a composite. The reinforcement will carry most of the load in a structural composite and provide strength, thermal stability and other properties to the composite. The different geometry shape of reinforcement will also results a different mechanical properties of a composite material. It is expected that the composite with woven form of reinforcement will have a better mechanical properties than the composite having rod as reinforcement in this study.

CHAPTER 2

LITERATURE REVIEW

2.1 Composites

Composite materials are engineered materials made from two or more constituent materials with significantly different physical or chemical properties and which remain separate and distinct on a macroscopic level within the finished structure. Generally, a composite is considered to be any multiphase material that exhibits a significant proportion of properties are realized (Callister, W.D., 2003).There is two categories of constituent materials: matrix and reinforcement. At least one portion of each type is required to produce these composite.

The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart their special mechanical and physical properties and enhance the matrix properties. Composite have three major categories which is polymer matrix composite (PMC), ceramic matrix composite (CMC) and metal matrix composite (MMC).

Composites are typically used in applications where a material of high strength and low weight is desired. For instance, while metals typically have high strength, they are among the heaviest materials. Plastics, while very light, tend to be comparatively weak. Ceramics in fiber form, while very strong, lack rigidity without additional support. Then, if these ceramic fibers are placed in plastics, the fibers can carry most of the force, while the plastic helps the fibers maintain the desired useful shape.

2.1.1 Composites properties

The final properties of a composite are determined by fiber content, matrix material, fiber material, fiber orientation, and to a smaller extent by the fiber length and distribution in the composite (Victor F. O., 2007). The reinforcing effects of the fiber in the composite are best explained by the rule of mixtures. In this rule, the properties of the composite depend directly on the volume fractions of each component in the mixture and the respective properties of the fiber and the matrix.

$$\sigma_{c}=\sigma_{f}V_{f}+\sigma_{m}V_{m} \text{ and } E_{c}=E_{f}V_{f}+E_{m}V_{m} \quad (i)$$

Where σ = Strength of the material, V= Volume fraction of component and E=Modulus of elasticity of the material.

The subscripts c is for the finished composite, f is for the fiber, and m is for the matrix (Victor F. O., 2007). The effects of increasing the amount of reinforcement in the composite are illustrated in Figure 2.1. At zero reinforcement the composite has the strength of the matrix, while as the content of reinforcement is increased (volume fraction), it increases in a linear manner.

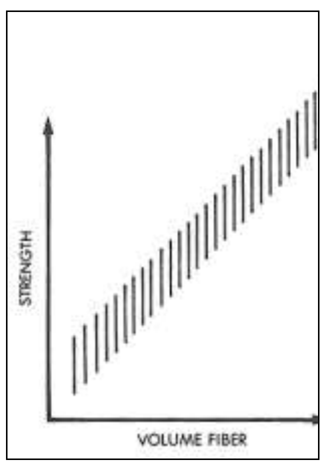

Figure 2.1: Graph shows as the fiber content increases the strength also will increase (Victor F. O., 2007).

2.2 Matrix

The matrix is the monolithic material into which the reinforcement is embedded, and is completely continuous. This means that there is a path through the matrix to any point in the material, two materials which is unlike, is sandwiched together. In structural applications, the matrix is usually a lighter metal such as aluminum, magnesium, or titanium (for MMC), and provides a compliant support for the reinforcement. Numerous metals have been used as matrices. The most important (for MMC) have been aluminum, titanium, magnesium, and copper alloys and superalloys (Kalpakjian, S., 2000).

Usually matrix have a lower density, stiffness, and strength compared to reinforcement material but when the matrix combine with reinforcement material it produces high strength, and stiffness and still low in density. The matrix material can be introduced to the reinforcement before or after the reinforcement material is placed into the mold cavity or onto the mold surface. The matrix material experiences a melding event, after which the part shape is essentially set. Depending upon the nature of the matrix material, this melding event can occur in various ways such as solidification from the melted state (Callister, W.D., 2003).

The matrix phase serves several functions. First it bind the reinforcement material together and act as the medium by which an externally applied stress and distributed to the reinforcement material. The second function of the matrix is to protect individual reinforcement material from surface damage as a result of mechanical abrasion or chemical reactions with the environment. Finally the matrix separates the individual reinforcement and, by virtue of its relative softness and plasticity, prevents the propagation of brittle cracks, which could result in catastrophic failure, in other words, matrix phase serves as a barrier to crack propagation (Callister, W.D., 2003).

2.2.1 Metal Matrix Composites

Metal matrix composite (MMC) commonly used a ductile and light metal as a matrix such materials include aluminum, magnesium and titanium. For high temperature applications, cobalt and cobalt-nickel alloy widely used.

As the matrix for metal matrix composite (MMC) is a ductile material these materials maybe utilized at higher service temperatures than their base metal counterparts; furthermore, the reinforcement may improve specific stiffness, specific strength, abrasion resistance, creep resistance, thermal conductivity, and dimensional stability. Some advantages of these materials over the polymer –matrix composite (PMC) include higher operating temperatures, non-flammability, and greater flammability, and greater resistance to degradation by organic fluids. MMC are much more expensive than PMC, and therefore their MMC use somewhat restricted (Kalpakjian, S., 2000).

The reinforcement for MMC can be particulates, continuous, discontinuous and whiskers. Commonly used of continuous fiber materials include carbon, silicon carbide, boron, alumina, and the refractory metals. The concentrations of reinforcement normally range between 10 % and 60 %. Discontinuous reinforcements consist primarily of silicon carbide whiskers, chopped fibers of alumina and carbon, and particulates of silicon carbide and alumina (Kalpakjian, S., 2000).

MMC application widely used in military, automotive and aerospace, in automotive industry MMC used to produce automotive disc brakes especially for high performance cars. MMC having silicon carbide fibers and a titanium matrix are being used for the skin, beams, stiffeners, and frames of the hypersonic aircraft under development. Other applications are in bicycle frames and sporting goods. Studies are in progress on developing techniques for optimal bonding of fibers to the metal matrix.